SODIUM SULFATE DEPOSITS ALONG THE SOUTHEAST SHORE OF GREAT SALT LAKE, SALT LAKE AND TOOELE COUNTIES, UTAH

BY STEPHEN R. WILSON AND FRANK L. WIDEMAN

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1/ Mining engineer, Bureau of Mines, Region III, Salt Lake City, Utah.

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INTRODUCTION

This paper is one of a series published by the Bureau of Mines on the mineral resources of the Nation. It describes briefly the occurrence of sodium sulfate in Salt Lake and Tooele Counties, Utah, presents data on sampling, and describes extraction and refining raw material and a mining research project that has been conducted on the deposits.

ACKNOWLEDGMENTS

Acknowledgments are given to the Tintic Standard Mining Co., Salt Lake City, Utah, and Bartlett Chemicals, Inc., New Orleans, La., for permission to use data obtained by the companies. The authors also acknowledge the courtesy of J. A. Marsh and H. K. Thurber, geologists and mining engineers, for permission to use information in reports prepared by them.

LOCATION AND ACCESSIBILITY

Deposits of sodium sulfate have been explored in two areas on the southeast shore of the Great Salt Lake in Salt Lake and Tooele Counties, Utah (fig. 1). The deposits lie under the sand of gently sloping beaches between the present waterline of the Great Salt Lake and its meander line of the year 1856 (fig. 2); they are 2 to 10 feet above the present waterline of the lake.

Area 1 lies near and roughly parallel to U. S. Highway 40, approximately 15 miles from Salt Lake City. Area 2 is 4 to 7 miles southwest of area 1. U. S. Highway 40 passes within three-fourths mile of the east end of area 2. The towns of Garfield and Magna are within short distances of the deposits. Most of the inhabitants of these towns are employed by Kennecott Copper Corp. or American Smelting & Refining Co. in mining, milling, smelting, or refining ores of copper and products from the ores.

The Union Pacific and Western Pacific Railroads and the Salt Lake, Garfield & Western Railway traverse the immediate vicinity of the deposits. The Salt Lake, Garfield & Western Railway is an electrically operated line, with switching facilities to trunklines at Salt Lake City.

POWER

A 44-kv. transmission line passes near both areas. The transmission line is owned by the Utah Power & Light Co., a public-utility company that supplies electrical power to much of the industry, and to the homes in the northern part of Utah.

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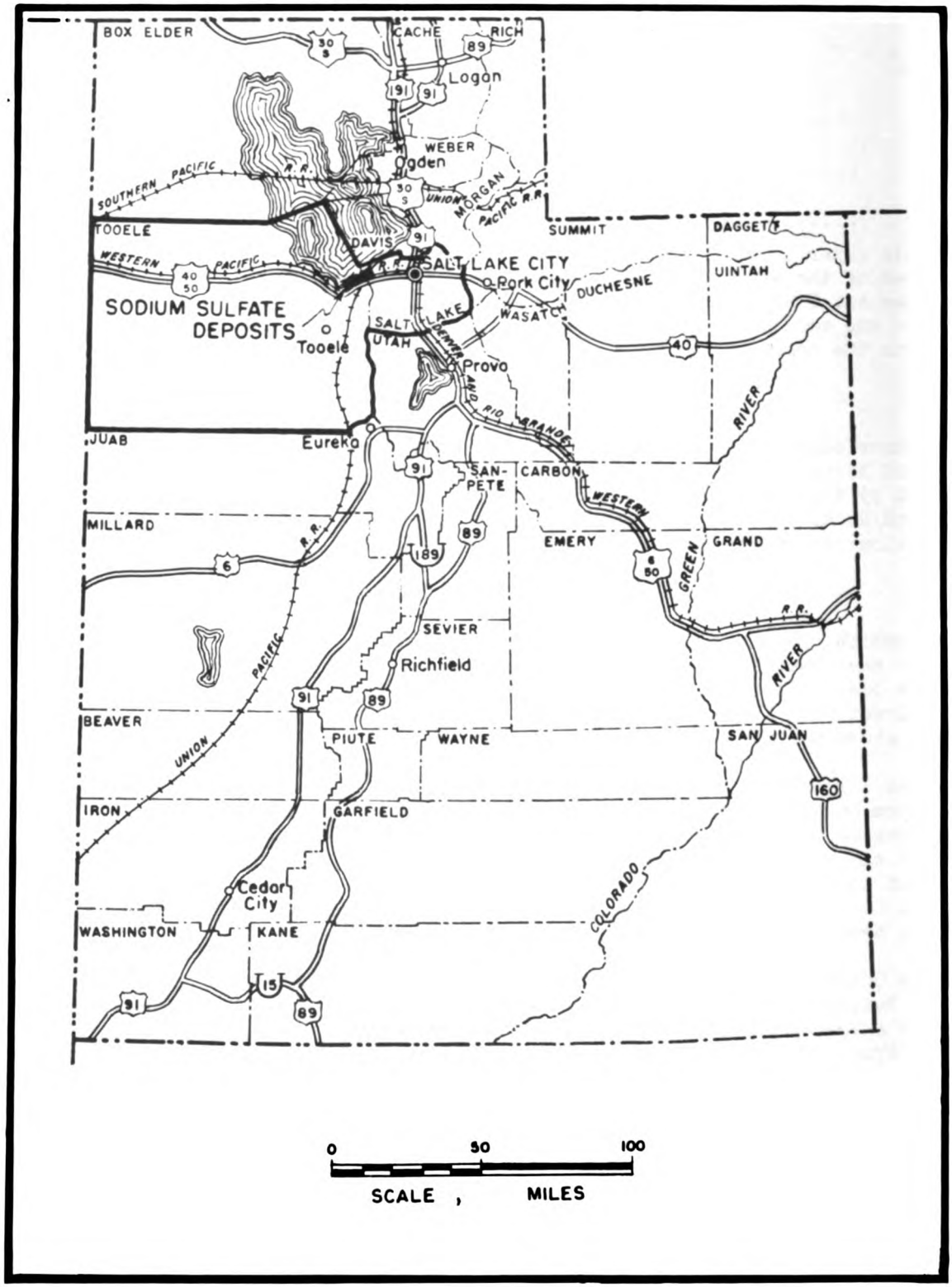

Figure 1. - Location map, Great Salt Lake sodium sulfate deposits.

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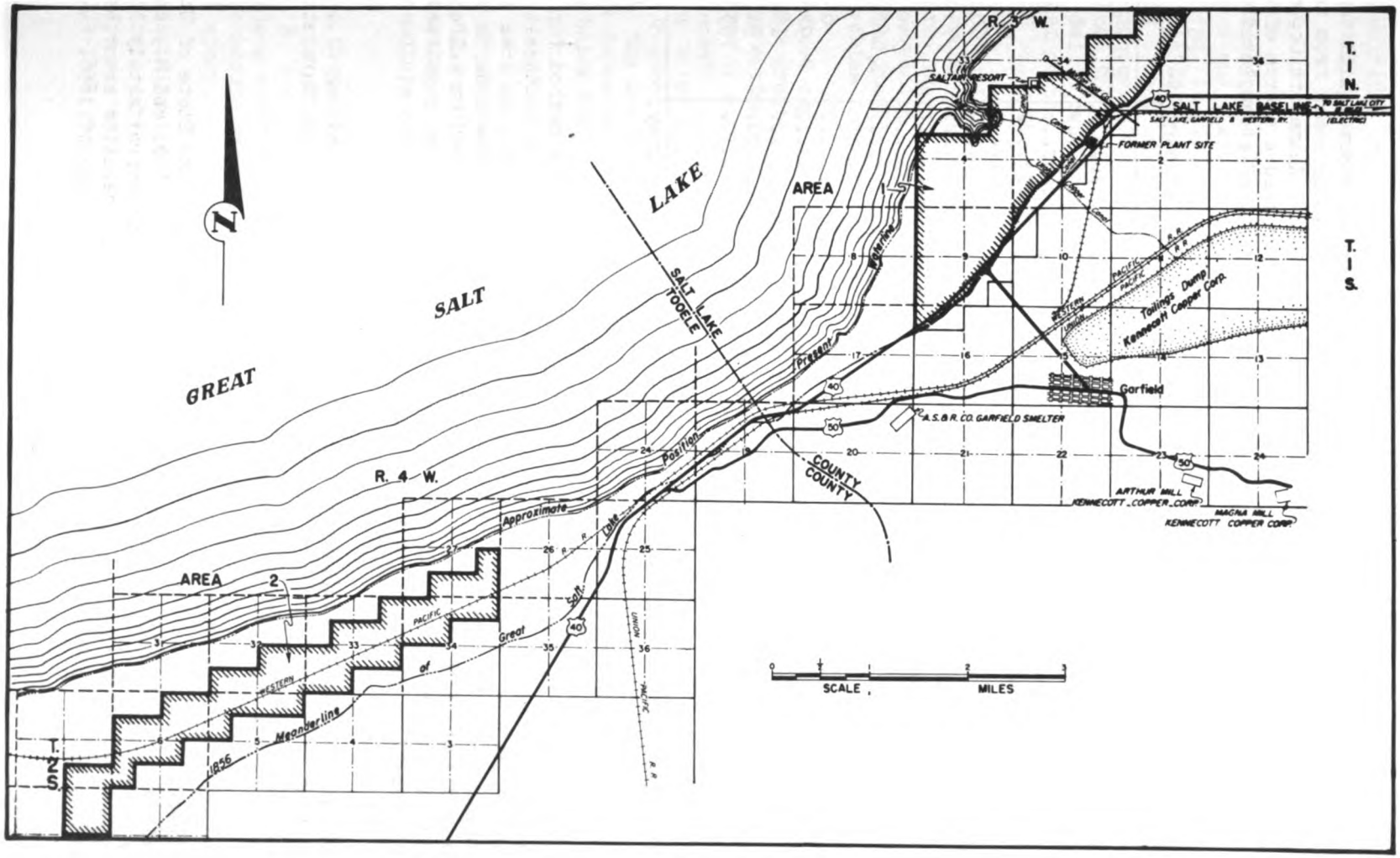

Figure 2. - Area map, Great Salt Lake sodium sulfate deposits.

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WATER SUPPLY

A canal that carries a large flow of water crosses area 1 about equidistant between the area's northeastern and southwestern limits. The water comes from tailings ponds of copper concentrators of the Utah Copper Division, Kennecott Copper Corp., a short distance easterly from area 1. The canal provided a source of water used in processing sodium sulfate. The results of an analysis of a sample of water taken from the canal in 1947 are given in table 1.

TABLE 1. - Analysis of Water from Utah Copper canal, February 1947[1/]

	p.p.m.
Dissolved solids	2,698
Loss on ignition	148
Silica	13
Iron and alumina oxides	5
Calcium	196
Magnesium	60
Sodium	593
Potassium	7
Sulfates	544
Chlorides	1,067
Alkalinity:	
Phenol	8
M.O.	92
Carbonates	16
Bicarbonates	91
Hardness as $CaCO_3$	735
Copper	Trace
pH	8.0

1/ Analysis made by N. E. McLachlan, chemist for Salt Lake City.

HISTORY

Salt Lake Sodium Products Co. was formed in 1932 to develop a method for extracting sodium sulfate from raw material in the deposits along the southeast shore of the Great Salt Lake. The company constructed a small pilot plant in area 1 near the Salt Lake, Garfield & Western Railway. A high-grade product was made in the pilot plant, and the company decided to erect a plant to produce sodium sulfate on a commercial scale. Production for the market was begun in 1939 and continued until 1940, when operations ceased, presumably because of difficulties with equipment and plant design.

Area 1 was sampled systematically in 1940 by Tintic Standard Mining Co., Salt Lake City, Utah. Some samples were taken from area 2 during 1947 for Bartlett Chemicals, Inc., New Orleans, La.

OWNERSHIP AND EXTENT

The deposits that have been explored are on land owned by the State of Utah. Area 1 comprises 1,780 acres in Tps. 1 N. and 1 S., R. 3 W., S.L.B. and M., and is in Salt Lake County. Area 2 is in Tooele County and contains approximately 1,762 acres in Tps. 1 and 2 S., Rs. 4 and 5 W., S.L.B. and M. The deposits occur between the present waterline of the Great Salt Lake and its meander line of 1856.

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The beach between areas 1 and 2 does not contain appreciable quantities of sodium sulfate. Much of the ground is held under lease by two companies that operate bathing resorts during the summer months.

DESCRIPTION OF DEPOSITS

The sodium sulfate deposits occur as hard, brittle beds of Glauber's salt mixed with sand and clay. The beds are covered by pervious sand composed of well-rounded grains and, in places, are underlain by clay. The beds seem to have been formed by variations in seasonal climatic conditions. Sodium sulfate crystals precipitate from the brines of the Great Salt Lake during the wintertime when temperatures are low. The crystals float on the water and are deposited on the beaches by prevailing winds from the northwest. As the temperature rises in the spring, the salt dissolves in its own water of crystallization. With the aid of rainwater it is carried down through the loose sands and precipitates where temperatures are lower. The distance below the surface where precipitation occurs appears to be about 20 inches.

Exploration indicates that the bed containing sodium sulfate varies from 3 to 6 feet in thickness in the section of area 1 southwest of the Salt Lake, Garfield & Western Railway. The portion northeast of the railroad appears to be essentially barren of sodium sulfate. The sodium sulfate appears to have been leached from the bed in the immediate vicinity of the Utah Copper canal. The thickness of the overburden varies from 12 to 37 inches in this area.

Limited exploration of area 2 indicates that the Glauber's-salt-bearing bed contains a greater percentage of sodium sulfate but is thinner than the bed in area 1. It is estimated that the bed has an average thickness of about 30 inches. The overburden is also indicated to be thinner over area 2 than in area 1.

Free water occurs at 2 horizons, 1 in the loose sand covering the bed containing the Glauber's salt and the other in the sand and clay below the salt bed. The water in the overburden carries sodium sulfate in solution, and clusters of Glauber's salt are deposited where small pools of the water have evaporated. The water in the stratum below the Glauber's-salt bed contains a high percentage of sodium chloride.

EXPLORATION AND SAMPLING

The deposits have been explored and sampled by auger holes drilled by hand. Precautions were taken to prevent contamination of the samples by the overburden and the water surrounding the hard sodium sulfate beds.

Area 1

Area 1 was sampled during the autumn of 1940 by the Tintic Standard Mining Co. A coordinate grid was established with its origin at the corner of secs. 3 and 4, T. 1 S., R. 3 W. (fig. 3). Points for sampling were established by transit and stadia along section and quarter-section lines at about 1,320-foot intervals, except in the immediate vicinity of the mining operations, where samples were taken 500 to 600 feet apart.

At sampling positions all overburden was removed from spaces with about 4-foot radii by hand or by caterpillar tractor. Small dams around the holes or casings of 2-inch pipe prevented water from entering the drill holes. The holes were drilled with 1-1/4-inch rock augers or coal augers of various lengths to 6 feet.

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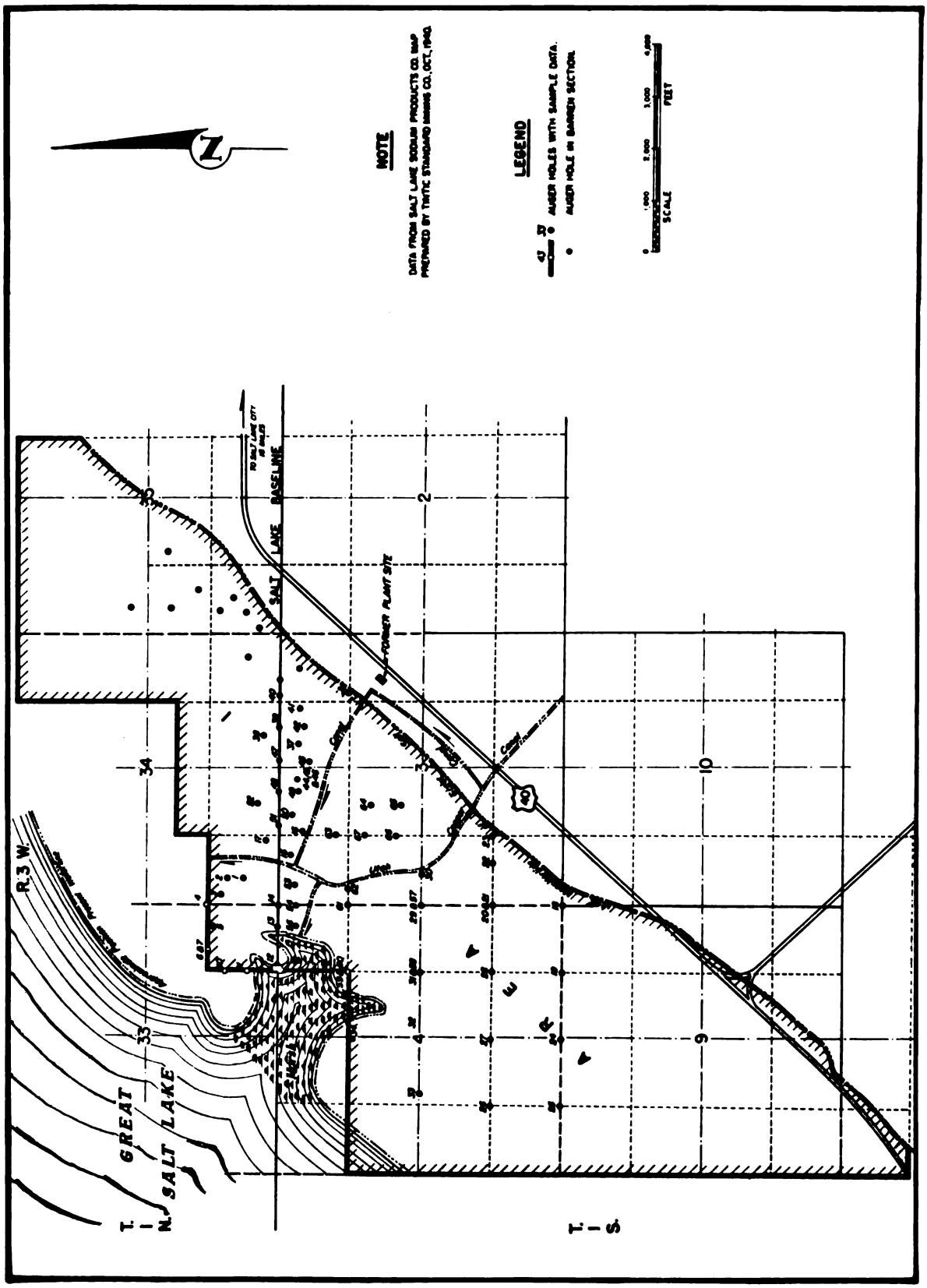

Figure 3. - Sample location map, area 1, Great Salt Lake sodium sulfate deposits.

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Drilling into the bed continued until drainage water seeping into the hole made a sludge of the cuttings. Sludge samples were taken only when it was impossible to obtain dry samples. Check samples were taken at certain places to compare dry samples with sludge samples. When it was necessary to take sludge samples, they were allowed to stand overnight; and the water, saturated with sodium sulfate, was decanted before the sample was analyzed. It was assumed that the water percolating into the hole represented a saturated solution and that discarding this water did not alter the value of the sample cuttings.

Samples from some holes were taken at three intervals, and it was found that the Glauber's salt content is essentially uniform in distribution in the bed. The top of the salt bed is harder and may contain a higher percentage of Glauber's salt for the first few inches.

The cuttings from the holes were thoroughly mixed and split in such a manner that each sample filled a 1-quart fruit jar. The jar was sealed and kept airtight until the sample was analyzed.

The results of analyses of samples taken from area 1 are given in table 2.

Area 2

The eastern part of area 2 was sampled during 1947 for Bartlett Chemicals, Inc., New Orleans, La. Sampling methods and spacing of samples in this area were identical with those used in area 1 during 1940, except that four holes in area 2 were drilled roughly parallel to tracks of the Western Pacific Railroad southwest of the main area of sampling (fig. 4).

The results of analyses of samples from area 2 are given in table 3.

PROCESS OF SALT LAKE SODIUM PRODUCTS CO.

Mining Raw Material

The layer of sand above the sodium sulfate beds was first pushed from the area designated to be mined, with a bulldozer. The hard, brittle layer of salt was loosened somewhat by blasting, after which the salt-bearing material was loaded into 5-ton cars by a power shovel. The cars were hauled to the refining plant by an oil-fired steam locomotive. The raw material was dumped into a small pocket.

Refining

The raw material passed from the ore pocket to a set of cracking rolls, where it was broken to a maximum size of 3 inches. The material then passed to a tank, where the sodium sulfate was dissolved by live steam. The pulp, consisting of sand and a small amount of clay suspended in a solution of sodium sulfate, passed through classifiers, where the sand was removed and washed to free it from mother liquor. The solution that overflowed the classifiers was pumped into settling tanks, where the clay settled. The clean solution was decanted from the settling tanks and passed to evaporators, where crystals of sodium sulfate formed as the water evaporated. The crystals were pumped to a classifier, where they were separated from the mother liquor. The crystals then passed through centrifuges to remove more mother liquor. The mother liquor from the classifier and centrifuges was returned to the evaporator. The crystals were dried in a revolving, gas-fired drier, resulting in a white and finely crystalline product averaging approximately 99 percent anhydrous sodium sulfate.

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TABLE 2. - Data pertaining to samples taken during 1940

SALT LAKE SODIUM PRODUCTS DEPOSIT

Analyses of Samples

Sample No.	Elev. above lake, feet	Depth of over-burden, inches	Thick. of Na_2SO_4		Thickness sampled		Water, percent			Percent on dry-				Na_2SO_4 on wet basis
			Feet	Inches	Feet	Inches	Total	Comb.	Free	Na_2SO_4	NaCl	H_2O Insol.	Na_2SO_4 + NaCl + Insol.	
1	4.74	22	5	7	5	7	26.75	18.0	8.8	19.4	3.3	76.7	99.4	14.2
2	4.53	21	4	10	4	10	24.0	15.2	8.8	15.8	2.8	80.5	99.1	12.0
3	4.22	22	3	0	3	0	29.8	22.8	7.0	25.4	2.8	70.8	99.0	18.0
4	4.08	21	3	8	3	8	19.0	12.3	6.7	12.0	2.8	84.8	99.6	9.7
5	3.83	22	5	5	5	5	26.25	18.4	7.9	19.6	3.0	76.6	99.2	14.5
6	3.28+	15	6	0	2	1/0	25.5	20.0	5.5	21.2	2.4	72.9	96.5	15.8
7	3.28+	15	6	0	4	2/0	29.2	14.3	14.9	16.0	5.8	75.5	97.3	11.3
8			6	0	4	1/0	26.5	23.0	3.5	24.6	1.7	70.2	96.5	18.1
9			6	0	2	2/0	23.25	11.9	11.4	12.3	3.7	80.7	96.7	9.4
10		15	6	0	6	0	25.5	18.4	7.1	19.5	3.2	75.1	97.8	14.5
11		19	6	0	3	0	23.5	15.9	7.6	16.4	2.7	76.9	96.0	12.5
12		21	6	0	2	0	30.0	24.9	5.1	27.9	3.4	65.6	96.9	19.6
13		22	6	0	4	0	24.75	17.2	7.6	18.1	2.5	76.5	97.1	13.6
14		29	5	0	4	0	28.0	17.4	10.6	19.0	3.3	72.9	95.2	13.7
15		33	4	6	3	0	22.75	14.5	8.3	14.7	3.1	78.6	96.4	11.4
16		30	3	0	3	0	21.5	11.8	9.7	11.9		80.2		9.3
17		24	6	0	3	0	24.5	11.4	13.1	11.9	3.1	74.4	89.4	9.0
18		36	3	0	3	0	20.0	2.8	17.2	2.7		86.7		2.2
19		30	3	6	3	0	33.0	16.1	16.9	18.9	5.8	72.0	96.7	12.7
20		24	6	0	3	1/0	29.5	17.6	11.9	19.8	4.0	73.2	97.0	13.9
21		24	6	0	3	2/0	35.5	15.5	20.0	18.9	4.0	71.1	94.0	12.2
22		26	3	6+	2	3/6	36.5	17.5	19.0	21.7	4.3	68.4	94.4	13.8
23	10.64	38	2	6	2	0	21.0	3.4	17.6	3.4	2.7	89.2	95.3	2.7
24		12	6	0	3	0	33.5	24.9	8.6	29.4	2.6	64.4	96.4	19.6
25	2.3	15	6	0	3	6	24.5	19.9	4.6	20.8	2.5	72.9	96.2	15.7
26	1.9	14	6	0	3	6	28.0	25.9	2.1	28.4	2.4	65.1	95.9	20.4
27	4.4	37	3	6+	1	4	21.0	17.0	4.0	17.0	2.8	75.6	95.4	13.4
28	6.72	28	3	0+	1	0	21.0	6.1	14.9	6.1	1.9	88.1	96.1	4.8
29	7.54	24	3	6+	2	0	23.5	8.0	15.5	8.2	2.2	84.5	94.9	6.3
30	9.05	37	2	6+	2	0	22.0	6.1	15.9	6.2	1.1	89.6	96.9	4.8
31	5.27	15	4	0	2	6	28.5	21.7	6.8	23.9	4.3	68.9	97.1	17.1
32	3.9	17	4	0+	3	0	15.5	13.3	2.2	12.4	4.4	82.2	99.0	10.5
33	1.36	20	4	0+	2	0	20.0	14.6	5.4	14.4	3.8	79.1	97.3	11.5
34	2.94	16	4	6+	4	0	27.5	13.1	14.4	14.2	6.7	75.7	96.6	10.3
35	3.48	17	4	0+	2	0	26.0	13.3	12.7	14.2	5.1	78.2	97.5	10.5
36	7.8	26	1	0	1	0	22.5	8.0	14.5	8.1	3.7	84.8	96.6	6.3
37	9.04	19	4	0+	3	0	26.0	21.9	4.1	23.4	5.3	70.3	99.0	17.3
38		29	3	0+	2	6+	25.0	11.7	13.3	12.2	4.9	79.3	96.4	9.2
39	9.38	24	3	0	3	0	32.0	17.1	14.9	19.8	5.8	70.7	96.3	13.5
40	10.11	30	1	6	1	6	24.5	13.8	10.7	14.4	5.7	76.8	96.9	10.9
41	10.19	30	3	0	2	0	22.5			20.3				15.7
42	9.81	29	3	0+	3	0	27.0			10.6				7.7
43	8.64	18	3	6	3	0	32.5			34.8				23.5
44	8.21	20	4	6	1	0	36.4			36.5				23.2
45	8.21	20	4	6	2	0	30.5			24.4				17.0
46	8.21	20	4	6	1	2/6	31.0			18.3				12.6
47	8.20	22	3	6	3	6	30.5			24.0				16.7
48	7.58	19	3	6	3	6	27.0			17.1				12.5
49		25	3	6	3	0	25.0			16.3				12.2
50		25	3	0	3	0	30.0			17.9				12.5
51	6.14	20	3	0	3	0	22.5			13.6				10.5
52	6.92	20	3	0	3	0	26.0			18.2				13.5
53		33	3	9	3	6	27.0			16.4				12.0
54		30	5	0	2	1/6	25.5			17.7				13.2
55		30	5	0	2	2/0	23.0			11.8				9.1
56		28	2	6	2	6	28.5			20.9				14.9
*57			3	6	3	0	30.5			28.0				19.5
**58			4	0	1	6	30.0			26.0				18.2
***59			6	0	3	1/6	22.5			14.0				10.9
60			6	0	1	2/6	22.0			7.4				5.8
61	5.95	24	6	0	3	0	21.5			4.5				3.5
62		22	5	6	3	6	29.5			6.4				4.5
63		28	3	0	2	4/0	20.0			11.4				9.1
64		40	1	0	1	4/0	24.0			20.3				15.4
65		30	2	0	2	0	30.5			20.4				14.2
66		20	3	6	3	6	29.0			16.4				11.6
67		24	3	0	2	0	24.0			7.4				5.6

1/ Upper.
2/ Lower.
3/ Sludge.
4/ Pipe.
* Check on Sample 29.
** Check on Sample 31.
*** Check on Sample 35.

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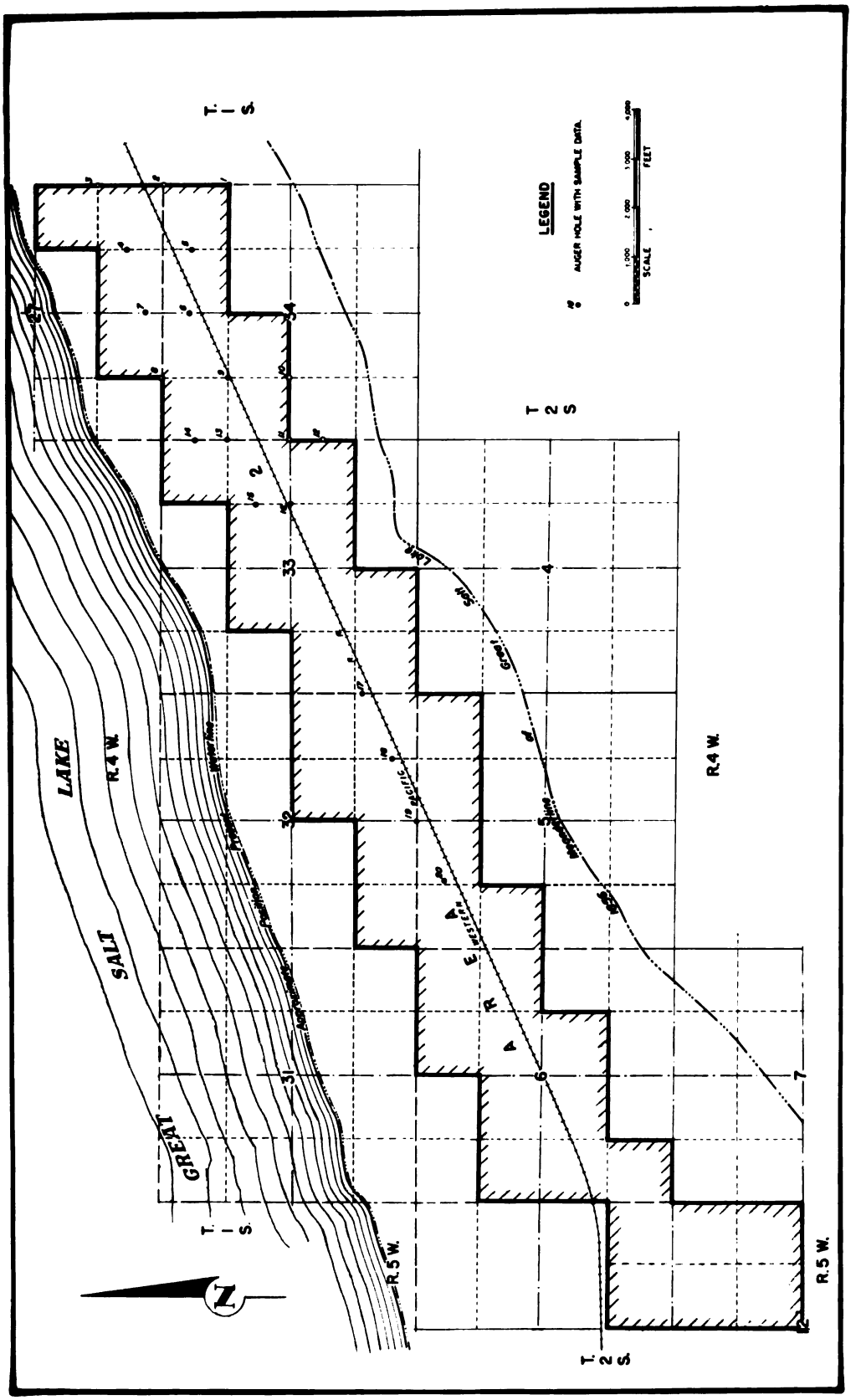

Figure 4. - Sample location map, area 2, Great Salt Lake sodium sulfate deposits.

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TABLE 3. - Analyses of samples taken in 1947, percent

Sample No.	Total moisture	Na_2SO_4 on dry basis	Na_2SO_4 on basis of $Na_2SO_4+10H_2O$	Na_2SO_4 on total moisture basis
1	-	23.09	17.85	-
2	-	30.73	22.14	-
3	-	17.35	14.23	-
4	-	26.45	19.83	-
5	-	15.20	12.75	-
6	49.0	15.92	13.23	8.12
7	63.1	29.10	21.25	10.72
8	85.0	50.80	30.94	7.65
9	59.6	36.60	25.00	14.80
10	50.5	36.00	24.76	17.82
11	19.2	13.30	11.38	10.76
12	20.5	13.75	11.71	10.93
13	27.0	30.76	22.17	22.43
14	28.1	18.20	14.77	13.10
15	21.5	26.76	19.95	20.98
16	16.5	10.66	9.38	8.90
17	35.1	30.64	22.10	19.90
18	29.0	24.82	18.90	17.63
19	32.2	25.43	19.35	17.27
20	28.0	23.85	18.04	17.17

EXPERIMENTAL MINING

During the spring of 1947 Bartlett Chemicals, Inc., conducted some experimental mining on the deposits. The site chosen for the work is in the NW1/4NE1/4 sec. 3, T. 1 S., R. 3 W. The overburden at the test site averages 20 inches in thickness. The sodium sulfate bed is indicated by auger holes to be about 3-1/2 feet thick at this locality.

The overburden was removed by a bulldozer from an area about 350 feet long by 50 feet wide. No difficulty was encountered in this work, as the sand can be separated readily from the sodium sulfate bed. The sand was piled along the edge of the cleared ground.

The second part of the experiment consisted of breaking and loading the sodium sulfate. A rooter, with 1 tooth set for a cutting depth of 16 inches, was pulled by a tractor. The work demonstrated that the bed could be broken by the rooter with little difficulty. A carryall scraper, 14- to 18-cubic-yard capacity, was used to load the broken material. The work demonstrated that the material can be readily loaded into the carryall.

Water in the deposits probably will cause some difficulty in mining the sodium sulfate beds, but it appears that the water can be controlled properly in a planned mining operation.

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